HERE'S HOW YOU CAN DO IT

IN

GEOLOGY

Section 3.

HERES HOW YOU CAN DO IT IN

GEOLOGY

CONTENTS

FOSSIL PRINT MAKING (SEN 1979, Vol. 28 No. 4)

Lyn Thickett, Wiley Park GHS

Every science teacher has no doubt tried to stimulate interest in geological history by getting his/her students to make 'fossils' using plaster of Paris. The usual result is a few mediocre casts, a frustrated teacher and blocked up sinks. A less demanding experiment involves the production of carbon prints.

The process requires ground up black chalk, sheets of paper, hard leaves such as eucalyptus leaves and Vaseline. The hard leaves are lightly but thoroughly coated with Vaseline on both sides, then dipped in the ground chalk. The chalk coated leaves are then carefully pressed between two sheets of paper to form the 'fossil leaf print'. It is important to emphasise that this is NOT the method by which carbonated fossils are formed in nature and the results of this experiment give only a facsimile of the real thing.

Although the experiment is simple enough for all levels of ability, there are some hints which will make the experiment almost foolproof.

Hints

1. Don't let the students collect soft or hairy leaves as these do not coat very well.
2. Used duplicating paper can be recycled in this process.
3. Black boot polish from an applicator can be used instead of chalk and Vaseline.
4. Have a genuine carbonated fossil on display so that the students can compare their fossil prints with the original.
5. The finished prints can make an ideal display for a notice board.

THREE DIMENSIONAL GEOLOGICAL MODELS (SEN 1981, Vol. 30 No. 2)
T. Midgley, Doonside HS

Three dimensional structures are often difficult to visualise. These models provide excellent correlation techniques for senior and higher ability Year 10 students. (Refer Fig.1.)

Monocline with fault – 3–D Model

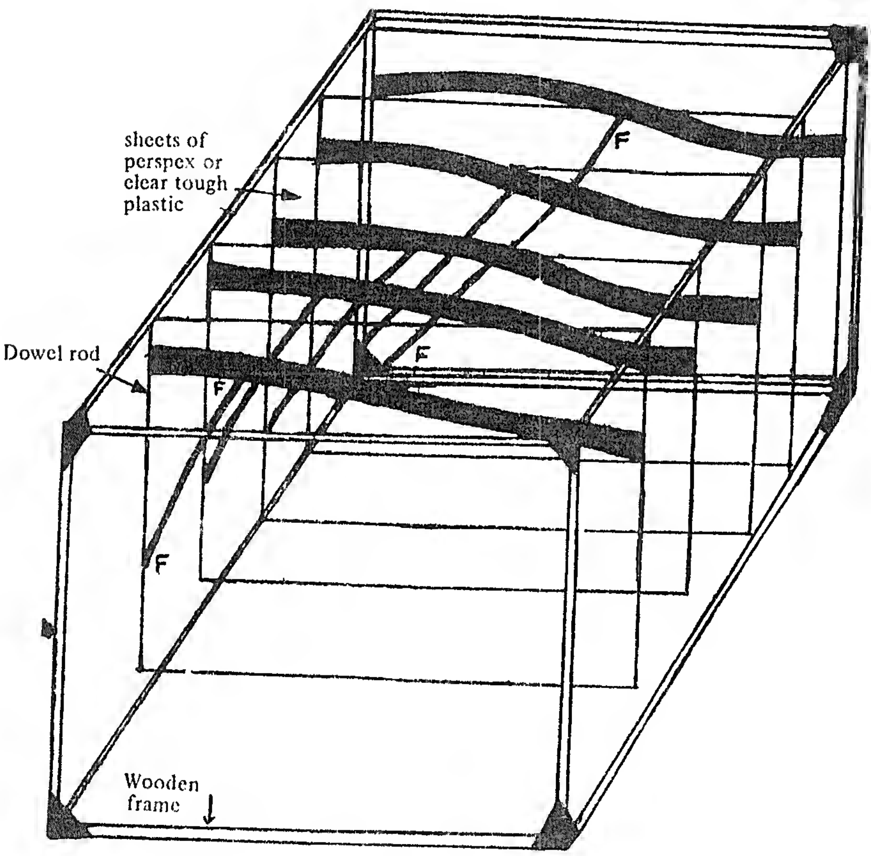


Figure 1.

The working unit consists of a wooden or metal frame, (size required depends upon storage space) upon which are hung geological x-sections. When viewed from the sides and ends a 3-D view is produced. Sections can be drawn by the pupils from "borehole data" supplied by –

The working unit consists of a wooden or metal frame, (size required depends upon storage space) upon which are hung geological cross-sections. When viewed from the sides and ends a 3-D view is produced. Sections can be drawn by the students from 'borehole data' supplied by:

a) the teacher
b) geological exercise books (see references)
c) real data from mining companies, e.g. Mt. Isa Mines.
Structures are drawn on with 'Texta' or OHP pens.

Suggestions

a) Use contrasting, clear colours.
b) Restrict any detailed sections, say, to 3-4 rock units.

At Doonside we have used OHP transparencies and strong, clear plastic sheets, but the use of clear perspex sheets is suggested for real clarity.
These can be reused by cleaning off with methylated spirits and any opacity which develops can be removed with 'Brasso' or some similar proprietary brand of metal cleaner.

Some suggestions for exercises are:

correlation of rock units
faults - vertical variation
folds - lateral variation
ore body shapes
facies changes, i.e. lateral variation of units
calculating ore body tonnages (Science Bulletin No. 25, p. 15)
sections of volcanoes

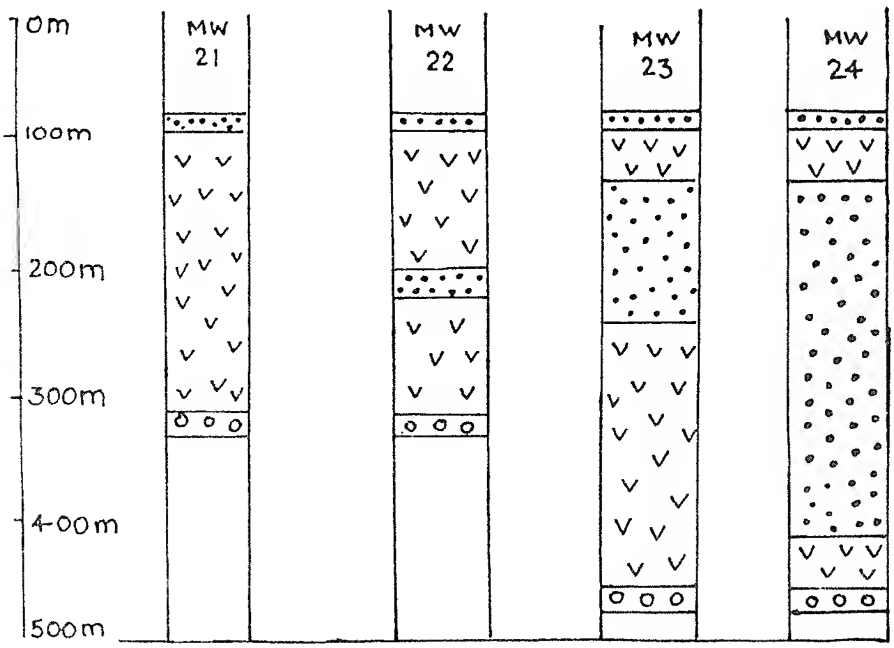


Figure 2.

An example of the procedure teachers might follow is given below.

1. Obtain n sheets of graph paper (n = number of cross-sections for your model).
2. Decide upon your scale, e.g. 1cm = 100 metres.
3. Draw whatever structure you would like to study on your first sheet (say Sheet A).
4. At regular intervals across the page 'drop' 'boreholes', eg. at 1,000metre spacing. (The result will be a pattern drilled grid.)
5. Transpose data from graph paper to columns (borehole cuts a bed, unit, fossil or structural feature; note depth on borehole log. (See Fig. 2.)
6. Draw other sections on your other sheets of graph paper, modifying the lateral variation if required. This can be done by laying one sheet over the previous section, held up on the window and traced with minor required differences, e. g. on attenuation of a fold.

Student Procedure

1. Student data sheets are issued. They now have to re plot the data given onto the plastic cross-sections with spirit pens (having been given a suitable scale).
2. Each student, or a small group, can be responsible for producing the finished section.
3. The group/individual places the section in the correct order in the frame.
4. Stand back, admire, realise that geology can be made interesting, constructively praise efforts, consider problems encountered, summarise the structural history.

Suitable books for data use are:

'Earth History in Maps and Diagrams', C.D. Ollier.

'Graded Exercises in Geological Mapping', K.R. Glasson and K.S. McDonnell.

'Coal Exploration, a Problem Solving Exercise in Geology', F.M.S. Tebbutt.

'Field Relations', The Open University.

Reprinted from Labscene, MW STA Journal.

CONTINENTAL DRIFT FOR JUNIOR SCIENCE (SEN 1983, Vol. 32 No. 3)

Tom Rozga, Sydney Technical HS

A. Gondwana Jigsaw - 1

About 250 million years ago all the continents were joined in one super continent, called Pangaea. The southern continents were called Gondwanaland. From 180 million years ago they have been moving apart. One of the first pieces of evidence for a super continent was that the coastlines could be matched to fit the continents together like a jigsaw. Alfred Wegener, a German scientist, proposed this idea in 1915.

1. Cut the continents out carefully and fit them into one continent which we will call Gondwanaland. The fit will not be perfect. Do not paste them onto your page as yet.
   NOTE: When students cut the continents out they can paste them separately onto firm cardboard, then cut around the continents again. This makes it much easier to try to fit them together.

About 250 million years ago when the Gondwana continents were joined, certain parts of them experienced glaciation. The glaciers deposited large amounts of sediment, called till which formed the rock tillite. The part of the continents where tillite has been found is shown in the segments below. As a glacier moves it is capable of scratching and cutting deep grooves in the underlying rock. The direction of the glacial grooves tells geologists the direction in which glaciers moved. These directions are shown by arrows.

2. Colour the segments red, then cut them out and paste them onto the matching positions on the continents and check your fit. Can you see how this adds evidence that the southern continents were once joined as one continent?

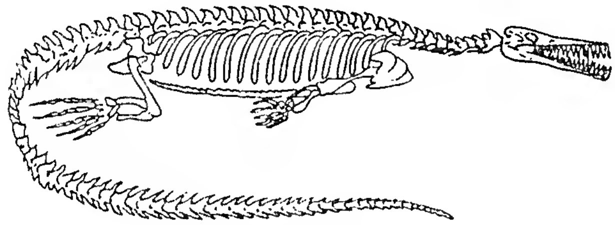
3. Paste the continent Gondwanaland onto your page.

B. Gondwana Jigsaw - 2

In the previous activity a perfect fit was not possible. This is because the edges of the continents are not at sea level, but at the edge of the continental shelves and therefore below sea level. The continents below show the margins of their continental shelves by means of dashed lines.

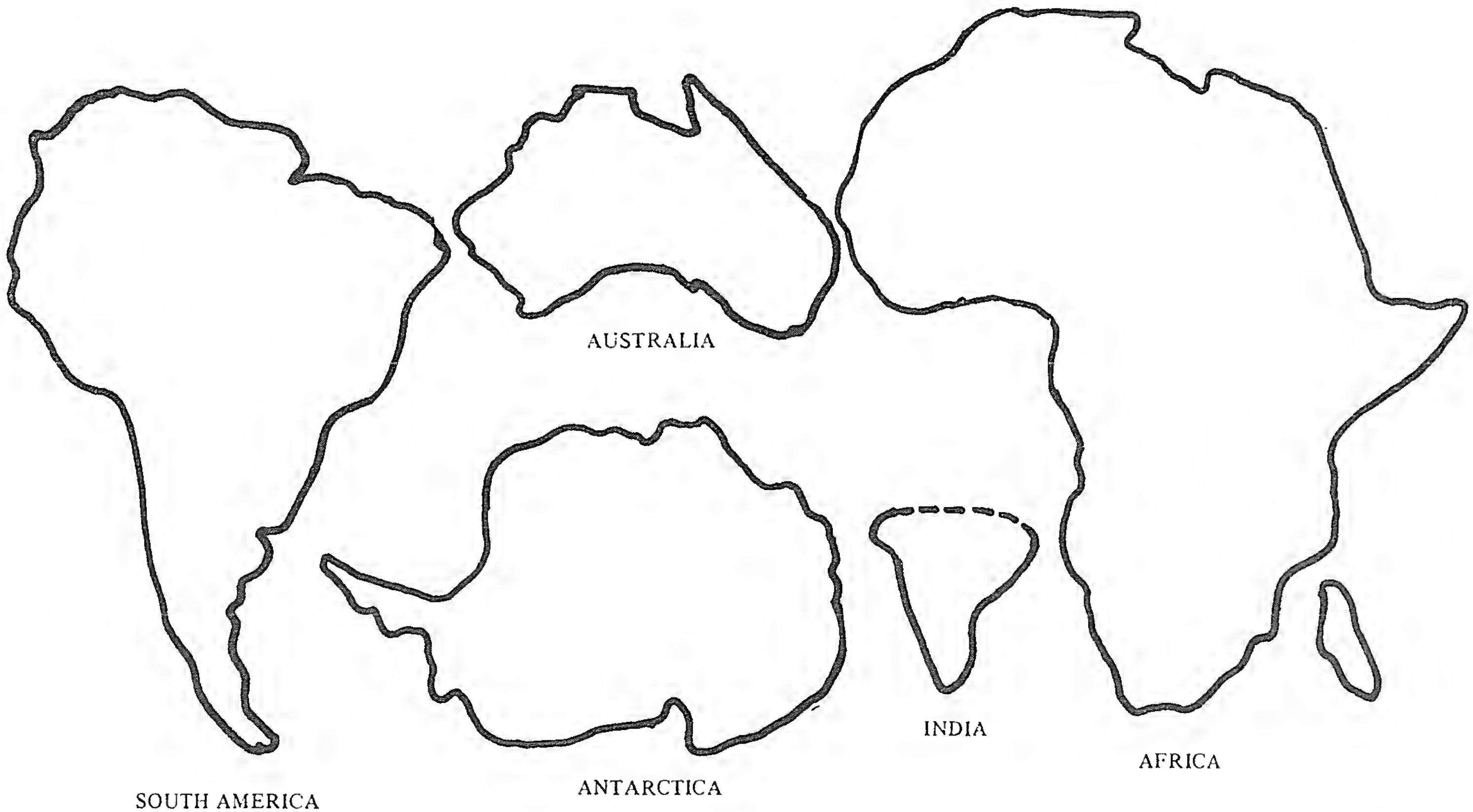
1. Cut out the continents around the dashed lines and arrange them on your page to obtain a better fit for Gondwanaland.

2. Colour the two segments below red. They represent the outcrop of the volcanic rock, basalt. The rock is about 100 million years old.
3. Cut the segments out and paste them onto the matching positions in Antarctica and Africa.
   How does this add further evidence that the southern continents were once joined?
4. Colour the two segments below green. They represent the areas where the fossils of the extinct reptile, Mesosaurus, is found in Africa and South America. It lived 220 million years ago.
5. Cut the segments out and paste them onto the matching positions on Africa and South America.
   It would be impossible for this reptile to evolve in isolation on these two continents at the same time. But Africa and South America were joined at the time it lived. Its existence in widely separated areas as fossils today is explained by Africa and South America drifting apart.
6. Paste the contents onto your page to form one super continent.

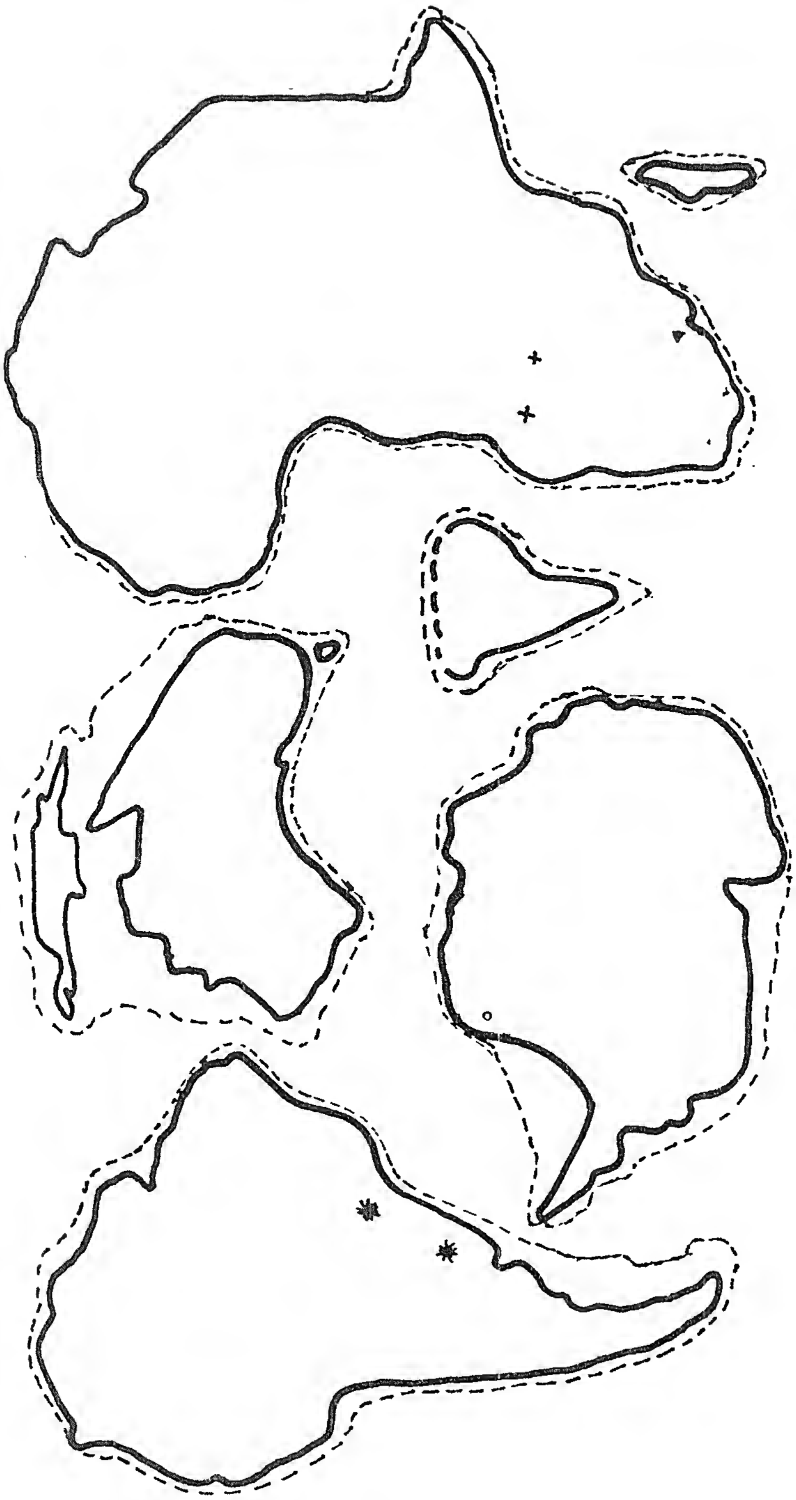


MESOSAURUS

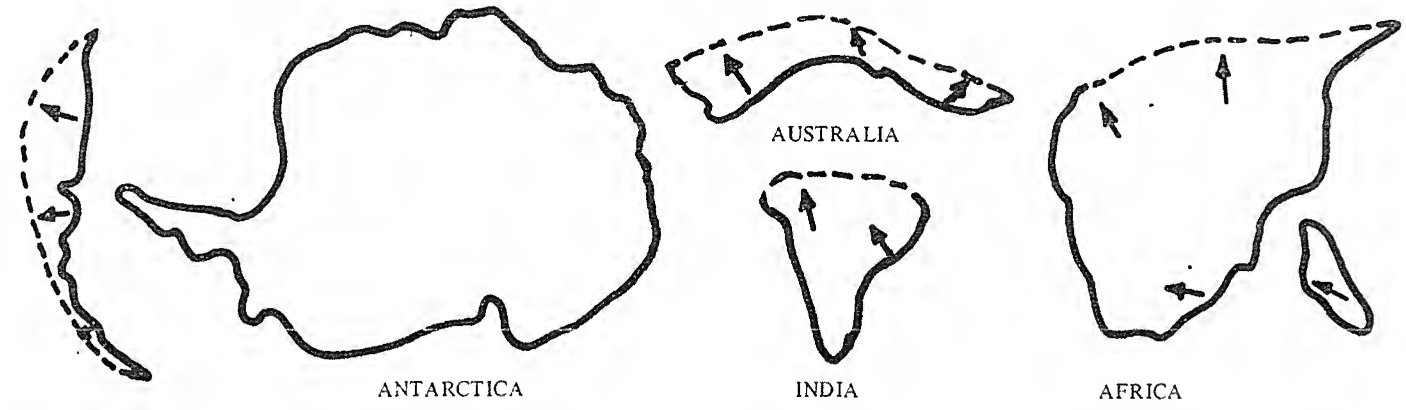
Paste the continents onto your page to form one super continent.



GONDWANA JIGSAW - 1 (Continents. Point 1)

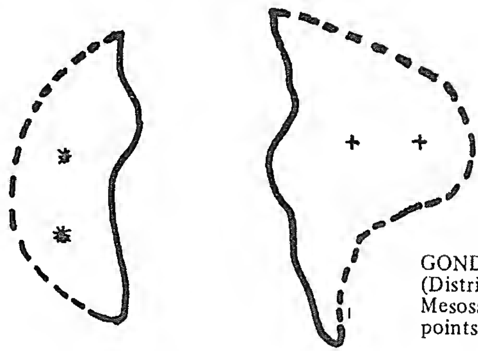


GONDWANA JIGSAW - 2 (Continents. Point 1)



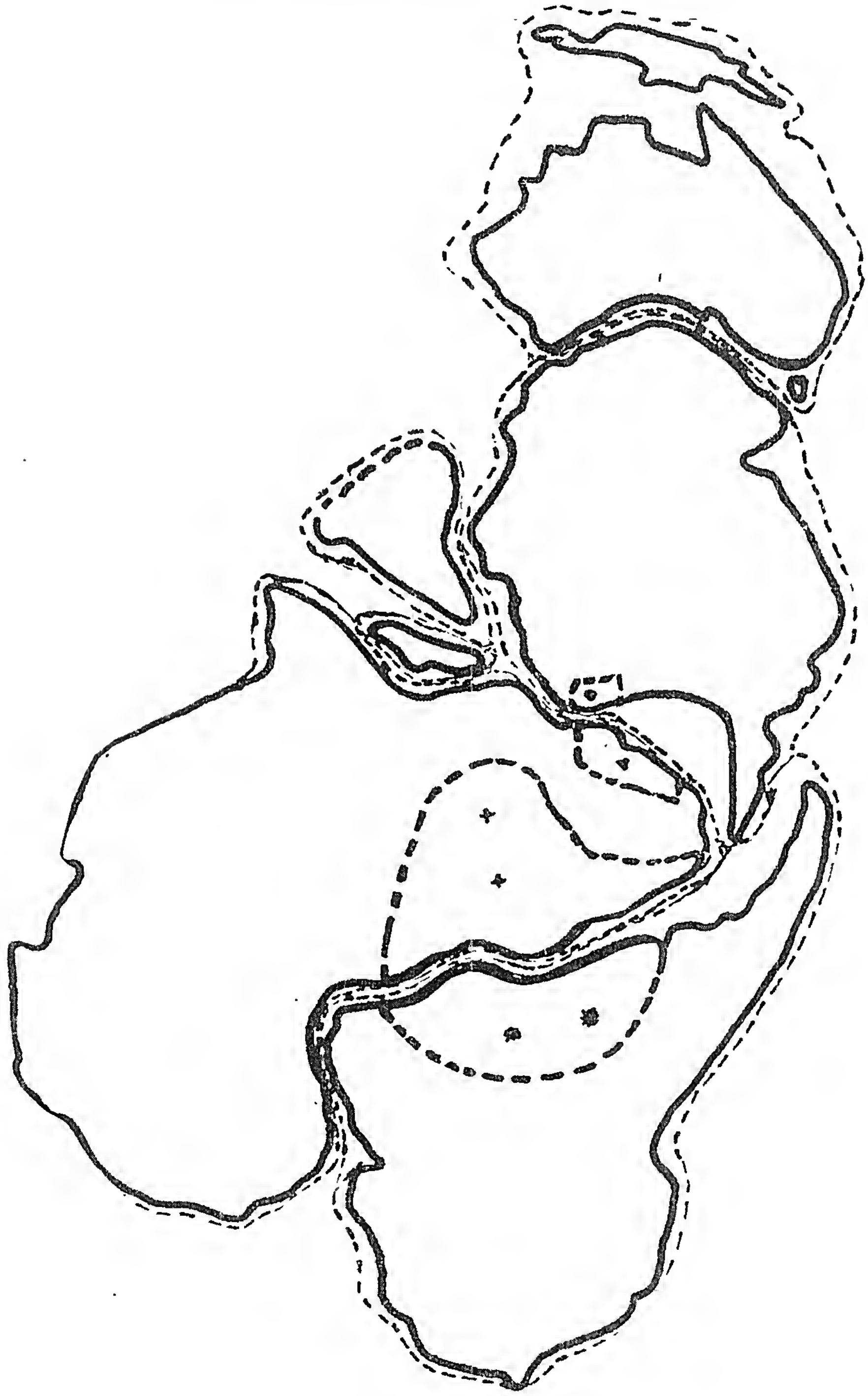
SEGMENTS OF THE CONTINENTS WHICH HAVE EXPERIENCED GLACIATION AND THE DIRECTION OF GLACIAL GROOVES. (GONDWANA JIGSAW - 1. Point 2)

GONDWANA JIGSAW - 2
(Basalt outcrops –
Points 2 and 3)



GONDWANA JIGSAW - 2
(Distribution of
Mesosaurus –
points 4 and 5)

AN OVERHEAD PROJECTION MASTER OF A POSSIBLE
SOLUTION TO GONDWANA JIGSAW - 2



AN OVERHEAD PROJECTION MASTER OF A POSSIBLE SOLUTION TO GONDWANA JIGSAW - 1

A SIMULATED VOLCANO (SEN 1984, Vol. 33 No. 3)
N.G. Hickson, Tempe HS

My suggestion for a superb simulated volcano.

1. Make a mound of damp soil in an enamel laboratory dish. (**NOT** sand, damp soil!)
2. Form a crater in the mound with dimensions, say 10cm in diameter to a depth of 5cm.
3. Spread 2 or 3 tablespoons of Poolchlor granules into the crater.
4. Pour up to 40mL of brake fluid over the granules and stand well back.
5. Over the ensuing minute observe the reaction. The effects go close to the real thing, right down to the acrid fumes and residual 'lava' in the cone. With more reagents, a lava flow may even occur.

Warning: this is an **extremely dangerous reaction.** It must be shown outdoors, with students some 5 metres clear. Obviously, the reagent names should be withheld.

The damp, loose soil seems to be the catalyst for the volcano like effects. In sand you just get a rapid, exothermic reaction. I am familiar with the multitude of volcano demonstrations, but this is the best, in my opinion.

FOSSILS (SEN 1984, Vol. 33 No. 4)
George Kelen

An alternative technique for producing 'fossils' in the laboratory which can be applied to individual, self-paced work.

Equipment
Plasticine, bees-wax candle, test tube, peg, bunsen.

Methods
A. Fossil Footprints

1. Make a shallow basin in the plasticine (the end of a ruler is useful).
2. Make 'footprint' patterns in the bottom.
3. Melt wax in the test tube and allow to cool **but** remain liquid.
4. Pour the wax into the basin. Allow to cool and solidify.
5. Peel off the plasticine to reveal tracks and a cast of the tracks.

B. Casts and Moulds

1. Push flat the top of a blob of plasticine.
2. Push in and remove a shell or any other object to make a mould.
3. Melt wax in the test tube and allow to cool but remain liquid.
4. Pour the wax into the mould. Allow to cool and solidify.
5. Remove plasticine to reveal cast (and with care, the mould).

Comments

1. The materials are reusable.
2. The amount of possible mess is reduced.
3. Finer moulding and casting detail is possible.
4. Using the hot wax could be a hazard.

ISOSTACY (SEN 1986, Vol. 35 No. 2)
Dr. W. D. Roots, Macquarie University

Although isostacy is a vital concept in tectonics, little is being published on isostatic theory and the two original models (of Pratt and Airey) remain with us still. Both models are correct, but as special cases of a general model.

Isostacy explains that if forces pushing upwards at a given point within the earth equal the forces pushing downwards, then the material that presently occupies that point will remain unmoved vertically (though it may move horizontally). If, say, the 'down' force is greater than the 'up' force, subsidence will occur until enough material has moved down *past the reference point* to reduce the down force to the value of the up force.

The forces that upset isostatic equilibrium are due to tectonic, erosional, sedimentary, volcanic or other processes. Tectonic and volcanic processes are fast, relative to the slow gravitational up and down warping processes that bring about isostatic balance. It is this difference in rate that is responsible for the growth of mountains when continents collide, for example.

If the forces that correct an isostatic imbalance were as fast as the processes that cause mountains to form, then the mountains would be in isostatic balance, and rather smaller than is usual now. This is the case along all the mid-ocean ridges (MOR), where the material beneath the ridge is hot and able to flow rapidly. MOR elevation is the result of heating and thinning of the lithosphere, expansion and melting and consequent reduction in the density of the material under the MOR and so the elevation of the MOR crest until isostatic equilibrium is achieved. There is no isostatic anomaly over the MOR or over its flanks (past crests) as the cooling process is slow and gravitational subsidence, in response to the increase in density of the lithosphere, is no slower. The maximum height that mountains can attain depends on the difference in the speed of the tectonic and gravitational processes operating at that place.

A good class demonstration of isostacy goes as follows:

1. Draw a 5cm by 5cm grid on a blackboard.
2. Draw a cross-section of a continental margin (continental and oceanic lithosphere) on the grid, to a depth of 110km, showing internal structure on a grand scale (5km water, 5km sediments, 5km basalt layer, a 20km thick layer, a 50km thick lid - the lithosphere below the crust - 25km of asthenosphere for the

ocean side and as appropriate for the continental side). Use h and v scales of 10km = 10cm.

3. Write the (rough) density in every square in four vertical columns evenly spaced across the board.
4. Sum all the densities in the columns and write this sum at the bottom of each column. (These represent gravitational forces of the material in each column, applied downward at the 110km level.)
5. Having seen the sums, select a figure that falls between the limits of the sums and declare this to be the lithostatic pressure at the 110km level (the upward force).
6. Now change the boundaries between the different layers of the cross-section by moving them up or down, making layers thicker or thinner, or change the densities you choose, until the (changed) sums all equal the lithostatic pressure. The rough cross-section you began with will be much modified in the process and will end up much closer to reality.

This exercise will leave you with a much clearer understanding of isostacy, but I suggest you do it alone before you try it on a class, so that your starting cross-section is reasonably close to reality.

IDENTIFICATION OF METAMORPHIC ROCKS (SEN 1987, Vol. 36 No. 1)

Kevin Burg, Benilde HS

Most Geology text books and their accompanying practical/laboratory manuals have good and easy to use schemes for identifying igneous and sedimentary rocks. However, there is a lack of any similar sort of schemes for identifying metamorphic rocks.

I have attempted to produce an easy to use dichotomous key for identifying the more common metamorphic rocks that are encountered in the senior Geology course.

I have modified one of the activities from the lab. manual of 'Perspectives of the Earth' to include this key. Your reactions, comments, suggested improvements would be appreciated.

Identifying Metamorphic Rocks

Purpose:
This activity is designed to introduce you to a system for identifying and describing metamorphic rocks.

Introduction:
Metamorphic processes are quite complex and difficult to simulate. Most of our information about metamorphism is derived from the study of metamorphic rocks in the field, in hand specimen and thin section. The classification of metamorphic rocks is also quite difficult because of the wide variety of metamorphic rocks. The make up of a metamorphic rock depends on three main criteria; the composition of the original rock, the kind of metamorphic change it has undergone and the degree of alteration it has experienced. However, a fairly simple classification system has been included in this exercise. As with all rock classification schemes, it is based on making careful observations of the TEXTURE and COMPOSITION of the rock.

Materials:

Metamorphic rock specimens, handlens, textbook.

Procedure:

1. For each specimen use the key below to identify the rock.
2. Record in a table the steps you took to identify the rock.
3. For each specimen identified, make a note of the following:
   a) fabric - the way the mineral grains are arranged
   b) grain size - measure or estimate
   c) mineralogy - the minerals present and estimate their abundance
   d) origin - what was the likely original rock?

Summary:

1. Describe the origin of foliated and non-foliated textures in metamorphic rocks.
2. List the foliated rocks in order of increasing grain size.
3. Account for this variation in grain size.

Key for Identifying Metamorphic Rocks

1. Is the rock foliated (i.e. does it have pronounced layering, banding, cleavage or alignment of minerals)?
   If yes go to 2; if no go to 18.
2. Does the rock appear to split easily into layers?
   If yes go to 3; if no go to 4.
3. Is the rock fine grained?
   If yes go to 6; if no go to 5.
4. Does the rock contain abundant mica flakes, or other flaky or elongated minerals?
   If yes go to 7; if no go to 8.
5. Does the rock contain abundant, easily visible mica flakes, or other flaky or elongated minerals?
   If yes go to 7; if no go to 13.
6. Does the rock have a perfectly smooth, fine grained cleavage surface?
   If yes go to 9; if no go to 10.
7. The rock is SCHIST. Name it according to its most abundant minerals.
8. Does the rock contain alternating bands of light and dark crystalline minerals?
   If yes go to 11; if no go to 15.
9. The rock is SLATE.
10. The rock is PHYLLITE.
11. Is the rock composed of >50% amphibole minerals?
    If yes go to 16; if no go to 12.
12. The rock is GNEISS. Name it according to its most abundant minerals.
13. Does the rock have a waxy feel or appearance?
    If yes go to 14; if no go to 15.
14. The rock is SERPENTINITE.
15. Does the rock contain >50% amphibole minerals?
    If yes go to 16; if no go to 25.
16. The rock is AMPHIBOLITE.
17. Does the rock react vigorously with dilute acid?
    If yes go 18; if no go to 19.
18. Does the rock contain >90% calcite?
    If yes go to 20; if no go to 21.
19. Does the rock have a spotted appearance?
    If yes go to 23; if no go to 24.

20. The rock is MARBLE.
21. The rock is CALC-SILICATE HORNFELS.
22. Does the rock appear to have bands or lenses of light and/or dark minerals?
    If yes go to 12; if no go to 13.
23. The rock is SPOTTED HORNFELS.
24. Is the rock composed of >90% quartz?
    If yes go to 25; if no go to 13.
25. The rock is QUARTZITE.
26. Does the rock contain appreciable amounts of a white fibrous mineral and green and brown minerals?
    If yes go to 21; if no go to 27.
27. The rock is HORNFELS. Name it according to its most abundant minerals.

THE PRINCIPLES OF MAGMATIC DIFFERENTIATION (SEN 1988, Vol. 37 No. 4)
Richard Cramp, Marist College North Shore

Aim:
1. To develop a better appreciation for the processes and principles involved in magnetic differentiation.
2. To demonstrate how, as crystallisation progresses, the chemical composition of a melt gradually alters.
3. To illustrate the order of crystallisation affects the integrity of the crystals which from, as available space for growth diminishes.

Theory: A mineral is, in essence, a chemical compound which is stable, in crystalline form, within a limited range of conditions. Thus minerals may be distinguished from one another not only by their chemistry but also by their 'freezing point', (that is, when they begin to form crystals).

A magma is a complex but homogeneous mixture of minerals and as such has no single point at which crystallisation takes place. Rather it has a range of crystallisation, (i.e. over several hundred ^{o}C). Over this range minerals will crystallise successively as the temperature decreases.

As each compound crystallises out of the melt the composition of the magma changes. Compounds which crystallise early are effectively removed from the magmatic mixture, leaving the way for the next compound to begin crystallisation; and so the process repeats itself.

These principles are clearly represented in Bowen's Reaction Series which not only classifies minerals by composition and structure but also by their crystallisation temperatures.

Those compounds which crystallise early have the freedom to develop a perfect form, whereas those that develop later lack the freedom of space in which to grow and consequently the form diminishes in quality with continued crystal growth.

Method:

1. Prepared solutions of $CoCl_2.2H_2O$, $Cu(NO_3)_2.6H_2O$, $CuSO_4.5H_2O$, $FeCl_2.4H_2O$, $K_2Cr_2O_7$ and NaCl are used.
   N.B. a) concentrations as low as 0.8M are quite adequate
   b) other salts may be used, but check for precipitation first.

2. Samples of each solution are poured into separate petri dishes and labelled. These are the controls by which the crystalline salts may later be identified.

3. These dishes are placed in a sunny, protected position where the crystals may develop by slow evaporation.

4. Prepare mixtures of any two or more of the prepared solutions in 1. in 80mL beakers, using approximately equal proportions. (Ensure that the solutions are thoroughly mixed to form a homogeneous mixture.)

5. The homogeneous mixtures are then poured into petri dishes, labelled left in a sunny, undisturbed corner to crystallise by evaporation. (This may take a day or two depending on the concentration of the prepared solutions.)

N.B. The following combinations yield the best results:
a) $K_2Cr_2O_7 + Cu(NO_3)_2$
b) $FeCl_2 + NaCl$
c) $CoCl_2 + NaCl$
d) $Cu(NO_3)_2 + NaCl$
e) $K_2Cr_2O_7 + Cu(NO_3)_2 + NaCl$

6. The students will be able to observe a sequential crystallisation of the salts in solution and if two or more coloured salts are used, a gradual change in colour will also be observed indicating the changing chemistry of the solution, e.g. mixing copper nitrate and potassium dichromate yields a transparent green solution. As the copper nitrate crystallises to form its characteristic blue crystals, the remaining solution becomes yellower, as is expected of potassium dichromate solution, indicating the changing chemical composition of the solution. Eventually, orange potassium dichromate crystals will form.

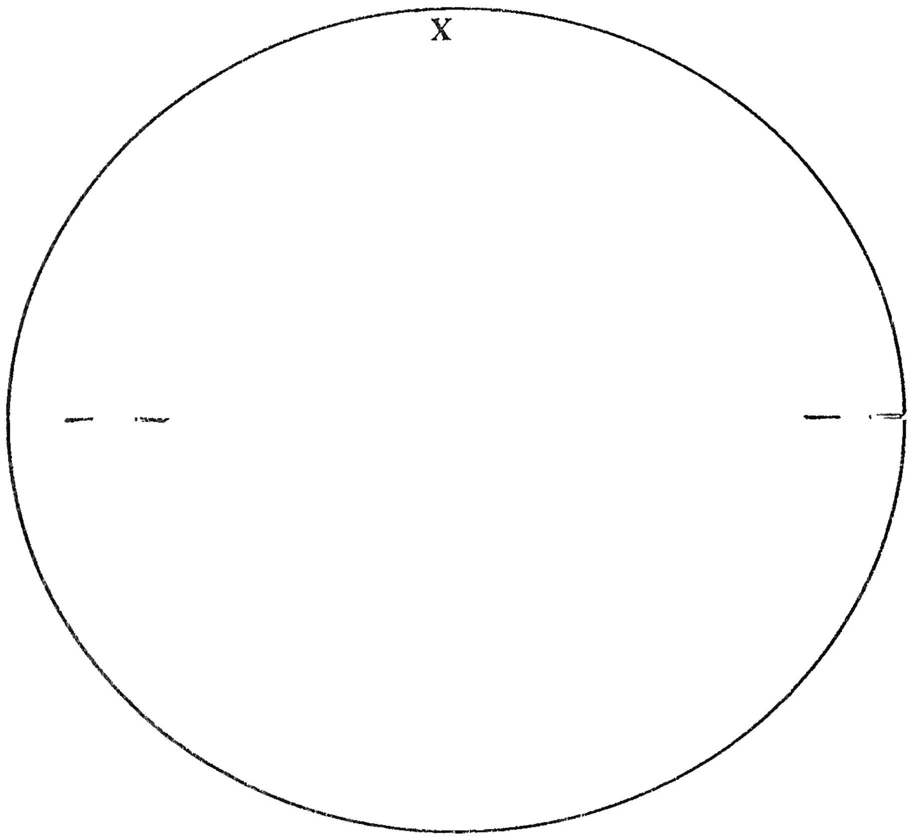
7. Once the solution has completely crystallised the petri dish may be inverted and held up to the light. The effect is like looking at a thin section through a petrological microscope or a photo-micrograph. The order of crystallisation may be determined as well as other relationships.
8. By placing polarising films in front of and behind the petri dish, it is possible to demonstrate the application PPL and XPL in petrogenesis.

In essence this experiment sets up easily affordable 'thin sections' and a very simple and cheap petrological microscope which can be used to demonstrate the principles of petrography and petrogenesis in petrology.

HOW BIG IS THE EARTH'S CENTRE? (SEN1988, Vol. 37 No. 4)

Using Light Rays to Model the Earth's Core

1. Set up the ray box to give **one** narrow light beam
2. Place semi-circular prisms from the kit in the inner circle. This area represents the Earth's Core
3. Shine the narrow light ray so that it passes **through** the point labelled X. Trace the path of the ray as it goes through the Earth. This shows the path taken by an earthquake wave through the Earth.
4. Trace at least ten different rays. All must pass through the point labelled X.



Questions

1. Do any rays travel directly through the Earth?

____

2. Is there an area in which **no** direct light rays which pass through the point labelled X are seen? Mark this zone by shading it on the diagram and labelling it **"Shadow Zone"**.

____

3. Suggest where the term **"Shadow Zone"** might have originated.

____

How Can the Size of the Earth's Core be Measured?

The simplest answer to this question is it cannot....at least not directly, but earthquakes give geologists a useful measuring stick for the Earth.

What to Do:

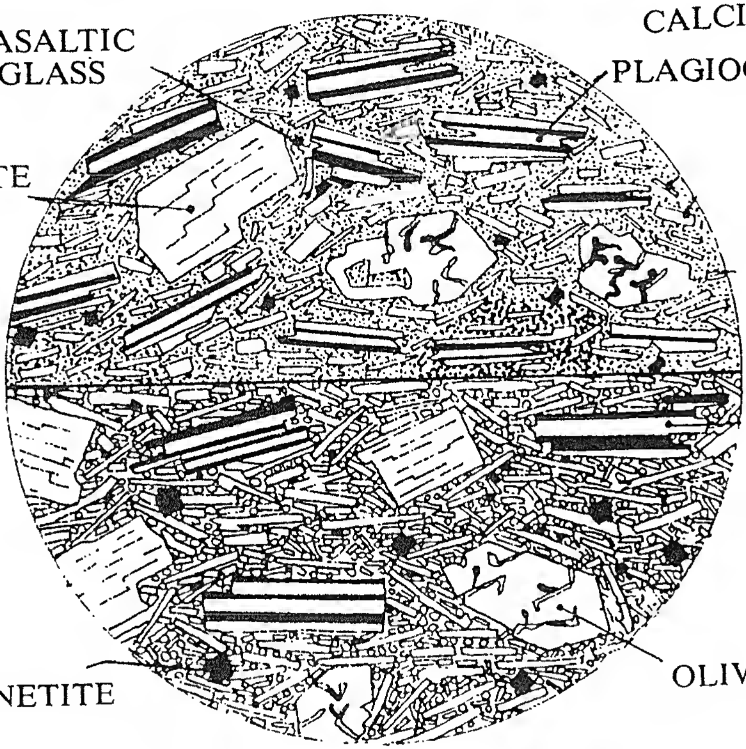
1. Measure the size of the "Earth" and "Core" in the last activity. Calculate the percentage of the Earth which is taken up by the Core. Also measure the angle at which the shadow zone starts. Record this information in the table below:
2. Draw another outer circle which is larger or smaller than the first. Find the start of the shadow zone for this "Earth" and again calculate the percentage of the Earth which is taken up by the core and record the data.
3. Repeat till you have at least **six** data points.
4. Draw a graph of percentage core against shadow zone starting angle.
5. The shadow zone of the real Earth starts at an angle of 143 degrees. Use your graph to find the percentage core you would expect.
6. The Earth has a diameter of 12,730 kilometres. What size should the core be?

TABLE OF RESULTS:

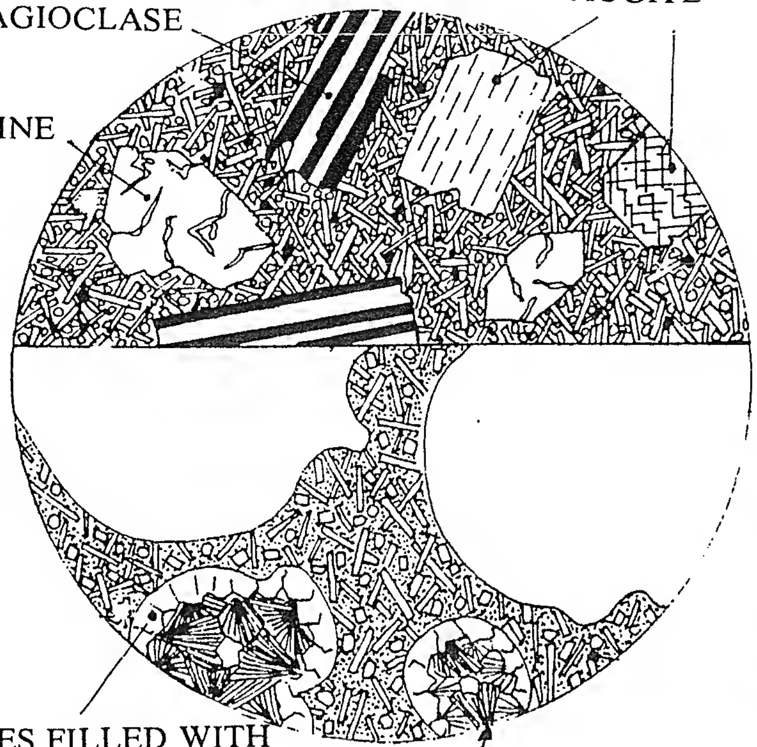
Size of inner circle "Earth"	Size of outer circle "Core"	Percentage Core	Shadow Zone	Starting Angle

CONCLUSION: The Earth's Core is about __________ km in size.

OVERHEAD PROJECTION MASTERS OF PHOTOMICROGRAPHS OF BASALTIC ROCKS



PHOTOMICROGRAPHS **A** AND **B** CONTAIN PHENOCRYSTS OF CALCIC PLAGIOCLASE, AUGITE AND OLIVINE. IN **B** THE GROUNDMASS IS FINELY CRYSTALLINE, CONTAINING LATH SHAPED PLAGIOCLASE CRYSTALS, GRANULES OF AUGITE AND SOME OLIVINE. THE GROUNDMASS IN **A** CONTAINS BASALTIC GLASS. NOTE THE ALIGNMENT OF CRYSTALS INDICATING A FLUIDAL FABRIC



VESICLES FILLED WITH SECONDARY CALCITE ON THE MARGINS, FOLLOWED INWARD BY CHALCEDONY.
SUCH FILLED VESICLES ARE CALLED AMYGDULES.

IN **C** THE GROUNDMASS SHOWS AN INTERGROWTH OF THE CONSTITUENT MINERALS. WHILE SUCH A FABRIC IS STILL COMMON IN FLOWS, IT IS CHARACTERISTIC OF BASALTIC MAGMA WHICH COOLS RAPIDLY IN THIN DYKES. IN **D** SMALL CAVITIES CALLED VESICLES, FORMED BY EXPANDING GASES IN THE LAVA, ARE PRESERVED.
SUCH A BASALT IS SAID TO POSSESS A VESICULAR TEXTURE.

OVERHEAD MASTERS OF BASALTIC ROCKS